# Chemistry I: Midterm Review 2014

## General Stuff

1. Density and formula: density is mass per unit volume $D = \frac{m}{V}$

   The units usually are g/cm$^3$ or g/L or g/mL

2. Define Accuracy and precision: Accuracy refers to the correctness of a single measurement. Accuracy is determined by comparing the measurement against the true or accepted value. Precision refers to how well experimental data and values agree with each other in multiple tests.

3. Metric system is the system of measurement based on units of ten; should know mm, cm, m and km. Also mL and L

## Matter and its changes

4. Describe the basic properties of matter in terms of mass and volume. Mass is how much matter something contains. Volume is how much space a given amount of matter occupies.

5. State the Law of Conservation of Matter and Energy: matter and energy cannot be created or destroyed only changed into different forms.

6. Define elements, compounds, and mixtures (provide 3 examples of each)

| | definition | 3 examples |
|---|---|---|
| element | Any substance that cannot be broken down by ordinary chemical means | Lead<br>Gold<br>chlorine |
| Mixture | Any substance that can be broken down by physical means such as distillation | Mud<br>Jello w/ fruit<br>concrete |
| compound | Any substance that can be broken down by ordinary chemical means | Water<br>Calcium chloride<br>Diphosphorus pentoxide |

6. List the physical and chemical properties metals, nonmetals and metalloids.

| | Physical properties | Chemical properties |
|---|---|---|
| metals | Can conduct heat<br>Can conduct electricity<br>Can bend<br>Can stretch<br>Have luster | React with acids<br>React with nonmetals to make ionic cmpds |
| nonmetals | Cannot conduct heat<br>Cannot conduct electricity<br>brittle<br>Have no luster | |
| metalloids | will exhibit properties of both metals and nonmetals. | |

7. Where are metals, nonmetals, and metalloids on periodic table? Metals can be found on the left side of the table and below the stair step. Metalloids can be found on the stair step starting at B and ending with At. Nonmetals are found in the upper right corner of the table to the right of the stair step.

8. Provide 5 examples of chemical change

   Light is released, heat is released, a gas (vapor) is released, a change in color, and a precipitate is formed and comes out of solution.

9. 4 things to start a chemical reaction
   Heat is applied to the reactants; substances are exposed to light, stirring, a catalyst is used.

10. Define physical and chemical changes and list 3 examples of each
    Physical changes are those changes that occur to a substance that does not change the elemental makeup of that compound. E.g. ice melting, gasoline evaporating, dew forming.

    Chemical changes are those changes that result in new substances with new physical properties being made. E.g. wood burning, sour mash fermenting, eggs frying

11. Define a Precipitate: is a very slightly soluble or insoluble compound that is produced in a chemical reaction. Usually collects on the bottom of the container (test tube).

## Chapter 3: Atomic structure

12. Define the following terms:
    a) An atom is the defining structure of an element, which cannot be broken by any chemical means. A typical atom consists of a nucleus of protons and neutrons with electrons orbiting this nucleus.

    b) Isotopes are atoms of the same element with differing number of neutrons

    c) The 3 basic atomic particles are proton, neutron and electron.

    d) Atomic number is the number of protons in the nucleus of an atom.

    e) Atomic mass is the sum of the number of neutrons and the number of protons

    f) Explain the following isotopic symbol and abbreviated version.

$^{222}_{86}Rn$

This is a complete isotopic which shows the atomic number and mass number along with the element symbol.

Ag-111

This is an abbreviated isotopic symbol which is comprised of the element symbol and the mass number of a particular iostope

13. Explain the significance of Ernest Rutherford's gold foil experiment.
    The gold foil experiment showed that atoms are mostly empty space. The center of the atom has a dense positively charged nucleus. This is referred to as a"nuclear" atom.

14. Define the quantum model of the atom.
    This model of the atom has a dense positively charged nucleus that contains 99 % of the mass comprised of neutrons and a number of protons (specific to each element).Located outside of the nucleus is the electron cloud. Within the $e^-$ cloud, electrons may be found in 3-D regions of space called orbitals. These orbitals have characteristic shapes which are described by wave mechanics and probability.

## Arrangement of Electron in Atoms

15. Define the following terms:

    a) Bright line spectrum is the spectra produced by electrons in atoms that are returning to the ground state from the excited state. When this occurs photons of specific frequency are produced and appear as bright lines.

    b) One quantum of energy is a package of energy described by Planck's equation $E = \hbar f$

c) One photon of light energy is a quanta of energy in the visible spectrum

d) Valence electrons are the electrons in the outermost energy level and are involved in the chemical bonding process.

16. Electron configuration is the distribution of electrons of an atom (or other physical structure) in atomic orbitals. For example, the electron configuration of the Ne atom is $1s^2\ 2s^2\ 2p^6$.

17. Orbital notation is a way to diagram electrons in their specific orbitals to see how atoms might bond.

**The Periodic Law**

18. Periodic Law states that the physical and chemical properties of the elements are functions of their atomic numbers.

19. Define the following terms:

a) Ionization energy is the energy needed to remove the most loosely held electron from an atom. Metals typically have low ionization energy. Nonmetals typically have high ionization energy.

b) Atomic radius of a element is a measure of the size of its atoms, usually the mean or typical distance from the nucleus to the boundary of the electron cloud.

c) Electronegativity is a measure of the attraction of an atom for electrons in a covalent bond.

20. Describe the trends of the following periodic properties as you go down a family / group on the Periodic Table

| | Trend top to bottom | Trend left to right |
|---|---|---|
| Ionization energy | Decreases because outermost electrons are shielded by the innermost electrons from the nucleus | Increases with greater nuclear charge |
| Atomic radius | Increases as more energy levels are added. (aufbau rule) | Decreases with greater nuclear charge pulling the electron cloud closer to nucleus. |
| Electronegativity | Electronegativities generally decrease from top to bottom down a group. Francium has the lowest electronegativity. | Electronegativities generally increase from left to right across a period with the Group VII element having the highest value for the period. |
| Reactivity | Metals increase<br>Nonmetals decrease | Decreases as you get closer to noble configuration. |

**Chemical bonds**

21. Define the following terms:

a) Coordinate covalent bond (also called a dative bond) is formed when one atom donates both of the electrons to form a single covalent bond. These electrons originate from the donor atom as an unshared pair.

b) Double/ triple covalent bonding occurs when the 2 atoms involved share 2 pair (4 $e^-$) or 3 pair of electrons the complete the octet.

c) Polyatomic ions (radicals) are covalently bonded species that have a charge thus making them ions, usually negative. There are 2 common polyatomic cations

d) Ionic bonding transfer of electrons between atoms that create ions of opposite charge that will attract to form a crystal (or lattice)

e) Define cation and anion
   1. Anion is a negatively charged ion
   2. Cation is a positively charged ion

22. Be able to determine polarity of covalent molecules (molecular polarity)

23. Determine polar and non-polar bond using electronegativity values.

**Chemical Composition:**

24. Define the following terms:
   a) Law of definite composition states that the elements in a given compound are always combined in the same proportion by mass. This law forms the basis for the definition of a chemical compound.

   b) Law of multiple proportions states that when two elements combine with each other to form more than one compound, the weights of one element that combine with a fixed weight of the other are in a ratio of small whole numbers. Example: CO and $CO_2$

   c) Molar masses of chemical compounds are equal to the sums of the atomic masses of all the atoms in the formula. The molar mass of any molecular compound is the mass in grams numerically equivalent to the sum of the atomic masses of the atoms in the molecular formula. If the formula used in calculating molar mass is the molecular formula, the formula weight computed is the molecular weight.

25. Label the following on the Periodic Table

a) Families
b) Periods
c) Alkali metals
d) Alkaline earth metals
e) Transition metals
f) Halogens
g) Noble gasses
h) Lanthanides
i) Actinides
j) "s" block
k) "p" block
l) "d" block

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 J | | | | | | | | | | | | | | | | | 2 |
| 3 | 4 | | | | | | | | | | | 5 | 6 | 7 A | 8 | 9 | 10 |
| 11 H | 12 | | | | | | | | | | | 13 | 14 | 15 | 16 | 17 B | 18 |
| 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 I | 27 | 28 | 29 | 30 | 31 C | 32 | 33 | 34 E | 35 | 36 |
| 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 D | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 |
| 55 | 56 F | 57 * | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 G |
| 87 | 88 | 89 * | 104 | 105 | 106 | 107 | 108 | 108 | 109 | 110 | 111 | | | | | | |

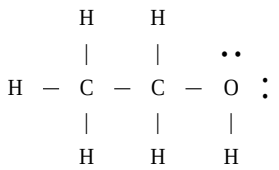
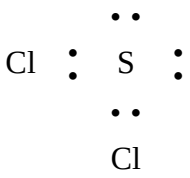
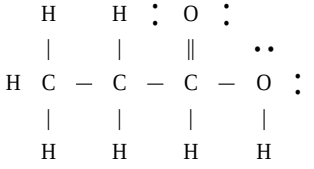
| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 58 * | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 |
| 90 * | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 | 101 | 102 | 103 |

1. For each capital letter above: Write the **e-config** , **Lewis dot symbols and oxidization #'s**

| element | e-configuration | Lewis Dot | Ox. # |
|---|---|---|---|
| A | $1s^2 2s^2 2p^3$ |  | -3 |
| B | $1s^2 2s^2 2p^6 3s^2 3p^5$ |  | -1 |
| C | $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^1$ |  | +3 |
| D | $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^6$ |  | +2 |
| E | $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^4$ |  | -2 |

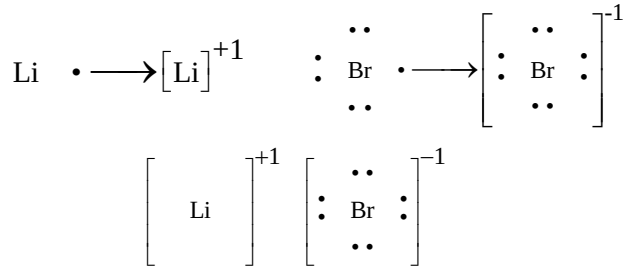
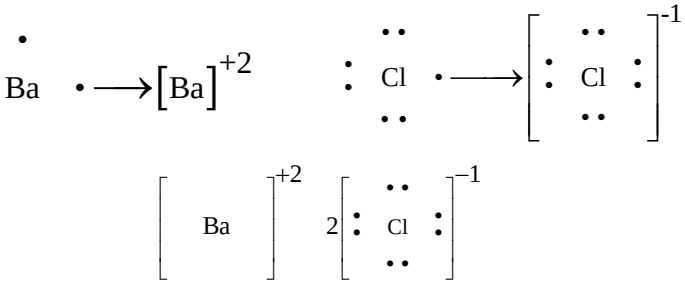
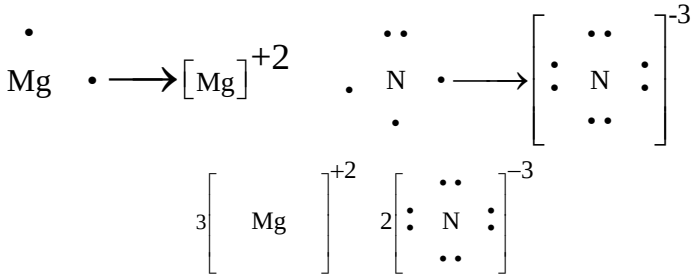
| | | | |
|---|---|---|---|
| F | $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2$ |  | +2 |
| G | $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6$ |  | 0 |
| H | $1s^2 2s^2 2p^6 3s^1$ |  | +1 |
| I | $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$ |  | +2 |
| J | $1s^1$ |  | +1 |

3. **Draw the following molecules and determine their shape**

| Molecule | Lewis structure | Geometry |
|---|---|---|
| $CH_3CH_2OH$ |  | linear |
| $SCl_2$ |  | bent |
| $CH_3CH_2COOH$ |  | ???? |

## Mid Year Problems: Show all WORK

**Draw examples of the following ionic bonds**

| Ionic Compound | Lewis drawing |
|---|---|
| LiBr |  |
| $BaCl_2$ |  |
| $Mg_3N_2$ |  |

**Write correct formulas** for the following compounds:

| | | |
|---|---|---|
| Potassium oxide<br>$K_2O$ | Carbon tertaiodide<br>$CI_4$ | Diphosphorus pentoxide<br>$P_2O_5$ |
| Aluminum sulfide<br>$Al_2S_3$ | Dinitrogen oxide<br>$N_2O$ | Silver sulfide<br>$Ag_2S$ |
| Copper (II) nitrate<br>$Cu(NO_3)_2$ | Ammonium phosphate<br>$(NH_4)_3PO_4$ | Ferrous sulfate<br>$FeSO_4$ |
| Lead (IV) oxide<br>$PbO_2$ | Cupric hydroxide<br>$Cu(OH)_2$ | Stannous bicarbonate<br>$Sn(HCO_3)_2$ |

2. **Correctly name** the following compounds:

| | | |
|---|---|---|
| $NH_4C_2H_3O_2$<br>Ammonium acetate | $Cr_20_3$<br>Chromium (III) oxide | $Pb(NO_3)_2$<br>Lead (II) nitrate OR<br>Plumbous nitrate |
| $Ag_2CrO_4$<br>Silver chromate | $P_4O_{10}$<br>Tetraphoshorus decoxide | $NBr_3$<br>Nitrogen tribromide |
| $Al_2(CrO_4)_3$<br>Aluminum chromate | $Sn(Cr_2O_7)_2$<br>Tin (II) dichromate OR<br>Stannous dichromate | $N_2O_4$<br>Dinitrogen tetroxide |

3. For the following calcium compounds: **write the formulas** and **find the % of calcium** in each

Calcium phosphate $Ca_3(PO_4)_2$ molar mass= 310 g/mol

$$\%\text{Ca} = \frac{120g}{310g} \times 100\% = 38.7\%$$

Calcium nitrate $Ca(NO_3)_2$ molar mass= 164 g/mol

$$\%\text{Ca} = \frac{40g}{164g} \times 100\% = 24.4\%$$

**Calculate the empirical formulas** for the following

52.2% **C** 13.00% **H** 34.80% **O**

$$C_{\frac{4.35}{2.18}}H_{\frac{13.0}{2.18}}O_{\frac{2.18}{2.18}} \Rightarrow C_2H_6O_1$$

$$\text{C} = \frac{52.2g}{12.0g} = 4.35 \text{ mol} \qquad \text{H} = \frac{13.00g}{1.0g} = 13.0 \text{ mol} \qquad \text{O} = \frac{34.80g}{16.0g} = 2.18 \text{ mol}$$

26.56 % **K** 35.41 % **Cr** 38.03 % **O**

$$K_{\frac{0.68}{0.68}}Cr_{\frac{0.68}{0.68}}O_{\frac{2.38}{0.68}} \Rightarrow KCrO_{3.5} \Rightarrow 2\left(KCrO_{3.5}\right) \Rightarrow K_2Cr_2O_7$$

$$\text{K} = \frac{26.56g}{39.1g} = 0.68 \text{ mol} \qquad \text{Cr} = \frac{35.41g}{51.9g} = 0.68 \text{ mol} \qquad \text{O} = \frac{38.03g}{15.9g} = 2.38 \text{ mol}$$

## Mid Year Problems: Show all WORK

4. **Calculate the molecular formula** for a compound that is 49.3% C 6.9% H and 43.8% O with a molar mass of 146 g/mol

$$C = \frac{49.3g}{12.0g} = 4.10 \text{ mol} \qquad H = \frac{6.9g}{1.0g} = 6.9 \text{ mol} \qquad O = \frac{43.8g}{15.9g} = 2.75 \text{ mol}$$

$C_{\frac{4.10}{2.75}}H_{\frac{6.9}{2.75}}O_{\frac{2.75}{2.75}} \Rightarrow C_{1.5}H_{2.5}O_1 \Rightarrow 2\left(C_{1.5}H_{2.5}O_1\right) \Rightarrow C_3H_5O_2$ Then compare the empirical FW with the molecular weight: $\frac{146g}{73g} = 2$ So the correct molecular formula

$2\left(C_3H_5O_2\right) \Rightarrow C_6H_{10}O_4$

5. **Complete and balance the following chemical reactions:**
6. **Identify the following reactions by type.**

7. $H_2 + Cl_2 \rightarrow 2\ HCl$ composition

8. $4\ Ag + O_2 \rightarrow 2\ Ag_2O$ composition

9. $2\,Li_2O \xrightarrow{\Delta} 4\ Li + O_2$ decomposition

10. $K_2CO_3 \xrightarrow{\Delta} K_2O + CO_2$ decomposition

11. $2\ CsHCO_3 \xrightarrow{\Delta} Cs_2O + 2\ CO_2 + H_2O$ decomposition

12. $2\ Al(OH)_3 \xrightarrow{\Delta} Al_2O_3 + 3\ H_2O$ decomposition

13. Al + NaCl $\rightarrow$ NO reaction single replacement

14. $Zn + Pb(NO_3)_2 \longrightarrow Zn(NO_3)_2 + Pb$ single replacement

15. $Br_2 + 2\ KI \longrightarrow 2\ KBr + I_2$ single replacement

16. $2\ C_2H_6 + 3\ O_2 \xrightarrow{\text{limited}} 4\ C + 6\ H_2O$ combustion (burning)

17. $C_2H_5OH + 3\ O_2 \longrightarrow 2\ CO_2 + 3\ H_2O$ combustion (burning)

18. $KOH + H_2SO_4 \longrightarrow K_2SO_4 + H_2O$ double replacement

19. $3NH_4OH + Al(NO_3)_3 \rightarrow 3NH_4\ NO_3 + Al_2(OH)_3$ double replacement

20. $6HCl + Fe_2S_3 \rightarrow 2FeCl_3 + 3H_2S$ double replacement

21. $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$ double replacement

22. $Mg_3N_2 + 6H_2O \rightarrow 3Mg(OH)_2 + 2NH_3$ double replacement

25. Explain each of the following formulas.
Define the variables and state the mathematical relationship

$E = \hbar f$

*E* is energy, $\hbar$ is Planck's constant and *f* is frequency. This is a direct mathematical relationship. Energy is directly related to the frequency.

$c = \lambda f$

C is the speed of light ($3.0 \times 10^8$ m/s), λ is wave length and *f* is frequency. This is an inverse relationship. As one variable increases the other will decrease. The product of the 2 variable will equal the speed of light.

$E = mc^2$

E is energy, m is mass (in kg) and c is the speed of light. This equations is a direct relationship. Mass can be converted to energy. The equation shows a small amount of energy can be converted to a huge amount of energy. This is found in nuclear reactions.